

CLAY SEAMS OR SO-CALLED HORSEBACKS NEAR
SPRINGFIELD, ILLINOIS

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Clay filled fissures in the form of clay seams are not uncommon in the Upper Carboniferous coal beds of the United States. They have been described from Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Iowa, Missouri and Kansas. In some cases the clay appears to have been derived from the fire clay below the coal, and in others its source seems to have been some horizon above the coal.

Describing clay seams in the Kansas coal beds, Crane² says:

"There is always an upward displacement of shale at the upper extremities of the clay veins . . . in all cases the clay in the clay veins is similar to that underlying the coal; and . . . the horizontal position of the coal or shale strata has not usually been disturbed."

Concerning their probable origin he states:

"Long after the coal was formed and consolidated almost to its present condition, vibratory movements of some kind fissured the strata including the coal beds. After the fissures were formed the fire clay below the coal was squeezed upward, filling the fissure by the process of ordinary creeping. The upturning of the shale laminæ near the upper part of the fissure would be readily produced by the upward movement of the clay under the power which forced it along."

His Fig. 23 on page 203 shows a clay seam in which the down bending of the edges of shale and coal indicate that the movement of the clay was downward in the fissure, while Fig. 29 on page 209 represents a clay seam in which the clay appears to have moved up from below the coal.

The coal field about Wier City is mentioned as showing very numerous clay seams. On page 164 is described coal on the Kepple farm in that vicinity, four feet thick, with a floor of good fire clay, having a roof composed of six feet of sandy shale above

¹ Illinois Geological Survey.

² Crane, Univ. Geol. Surv. Kan., Vol. III., pp. 211 and 212.

which occurs two feet of fire clay, which is succeeded by more sand and shale. The above conditions of roof and floor would seem to be favorable for the development of clay seams on the same principle as those occurring in the Springfield area.

Keyes¹ states that:

"Ruptures, or more or less vertical, simple fissures, which are merely a separation of different parts of the coal seams without displacement, are not uncommon in Iowa. Clay usually fills the fissure which may be from an inch to a foot or more in width."

From the figures which he gives of these clay seams, the direction of movement of the clay in the fissures cannot be determined.

Bain² has figured a clay seam in which the down bending of the edges of coal and roof slate at the top of the coal seam indicate the downward movement of the clay in the fissure, similar to those in the Springfield area where the fissure passes nearly vertically into the coal. The roof of the coal in this region consisted of one and one third feet of black, fissile shale, succeeded by about four feet of limestone above which were seven feet of pyritic shale.

Discussing clay veins in the Indiana coal seams Ashley³ says:

"They are usually associated with faults and are probably due to the action of the same forces. . . . In a few places the clay appears simply to fill the space made by the separation of the rocks on either side of the line of faulting. In most cases the coal and the rock on either side seem to have been broken up . . . and when the clay was forced up through this mass, it extended out into it, following lines of least resistance, and catching up masses of it in the main clay body."

In his sketches of clay seams, Figs. 3 and 4 on page 58 of this report, there seems to be indicated a down bending of the upper edge of the coal on the overhanging side of the fissure without any real faulting of the bed. On page 468 he describes a coal seam on the Conce land, four and one half feet thick, which is overlain by twenty-two inches of black shale, above which are three feet of clay shale. Of another mine, nearby, the fire clay

¹ Keyes, Iowa Geol. Surv., Vol. II., p. 189.

² Bain, Iowa Geol. Surv., Vol. V., p. 399.

³ Ashley, 23d Ann. Rept. Dept. Geol. and Nat. Res. of Indiana, p. 59.

is said to give no trouble creeping, possibly because too dry. Clay seams are said to be common in the coal in this vicinity.

The conditions here of a dry fire clay floor; a hard, black shale roof, followed by a three-foot bed of clay shale are consistent with the state of things in the No. 5 seam of the Springfield area.

Concerning the clay seams in Ohio coal beds, Orton¹ states that:

"Clay veins, one of the most serious drawbacks to mining in many fields, are connected with and proceed from the fire clay floor. They seem to have been formed in the earlier stages of the history of the coal seam by some inequality of pressure or resistance whereby the bottom clay was forced in thin sheets through the hardening coal."

In his report on the coals of Michigan Lane² says that clay-filled veins, or clay seams, are but little known in Michigan. An inspection of the various shaft sections given in this report shows a remarkably small amount of fire clay or soft shales associated with the coal seams, and a great predominance of sandstone and hard shale. Such strata associated with the coal beds would not be favorable for the development of clay seams.

In discussing clay veins, more especially those of the Pennsylvania coal field, Gresley³ thinks that the clay vein fissures may be placed in the category of earthquake phenomena. He says:

"The fissures remained open long enough to allow weathering and the gradual disintegration of their ragged sides. The character and aspect of the finer clay and the more fragmentary ingredients of the clay veins are such as to indicate that they were principally derived from the walls of the veins. In most cases the vein stuff comes by descent from the walls, in other cases they are intrusively filled by the underclays which have been squeezed up into the open cracks in the overlying coal."

It seems probable that clay seams have been formed in different ways under differing conditions of roof and floor, and varying degrees and kinds of strains to which the strata were subjected. It is not possible that earthquake phenomena or general crustal strains, such as produce widespread faulting, could be concerned

¹ Orton, *Geol. Surv. of Ohio*, Vol. V., p. 143.

² Lane, *Geol. Surv. of Mich.*, Vol. VIII., p. 126.

³ Gresley, *Bull. Geol. Soc. of Amer.*, Vol. IX., p. 35, *et seq.*

in the formation of the fissures of the clay seams in the Springfield region. Fractures from the above mentioned causes would not be limited to a few feet in vertical height, or to one particular coal seam, as in area under discussion.

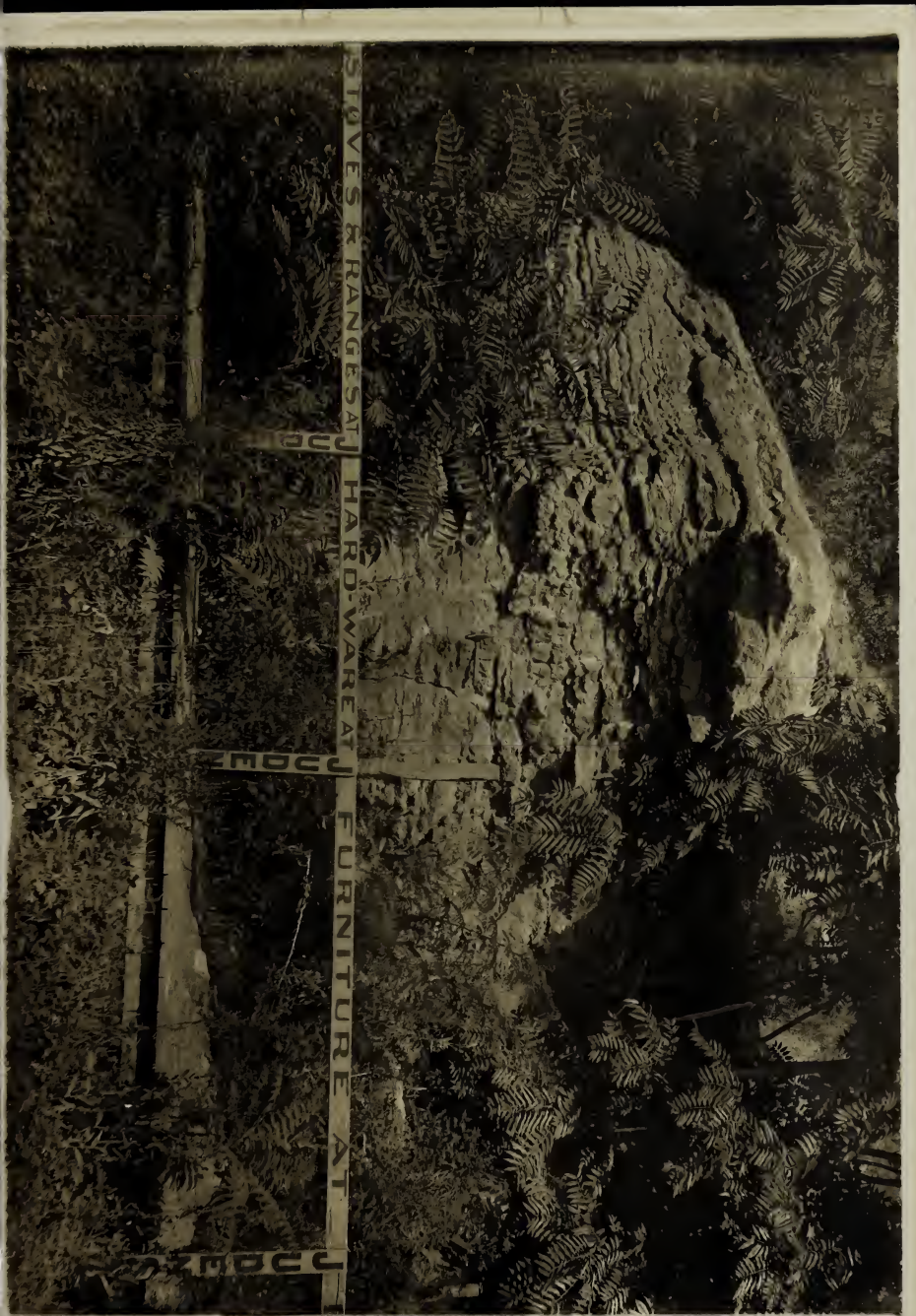
Clay Seams Near Springfield.—The principal coal seam exploited in western Illinois, over the area between Springfield and Peoria, was designated in the Worthen reports as No. 5. The following section shows the character of the strata associated with the No. 5 coal in the region about Springfield.

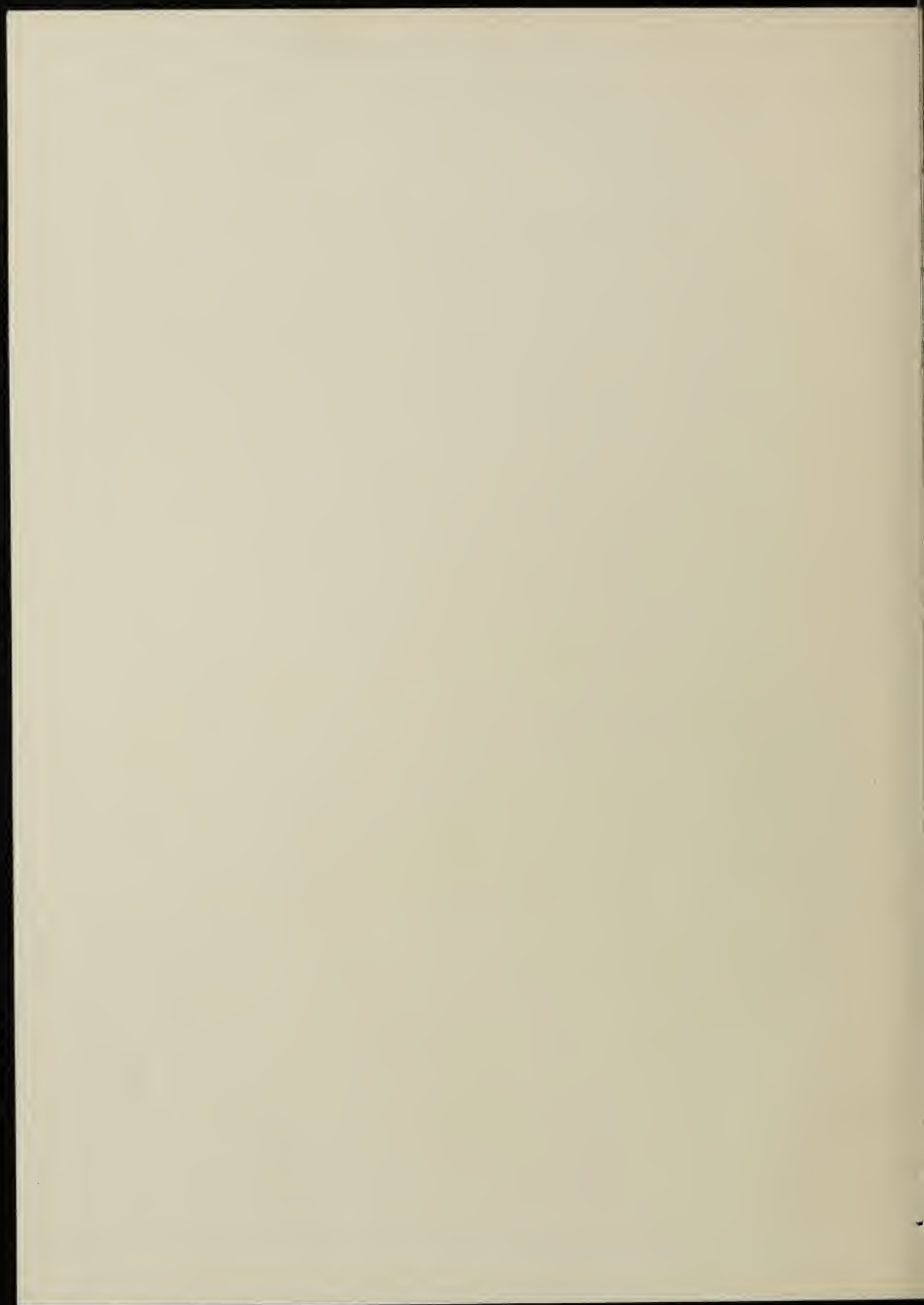
	Feet.
Sandstone or shale.....	10 to 30
Light gray shale or soapstone.....	1½ to 4
Limestone cap rock.....	½ to 1⅓
Black, fissile shale.....	2½ to 4½
Coal (No. 5).....	5 to 6½
Fire Clay.....	1½ to 5

One of the conspicuous features of the No. 5 coal seam is the presence of numerous clay-filled fissures that extend down into, or through, the coal seam from the overlying beds. The fissures are generally from two or three to sixteen inches in width, although the larger ones attain a width of three or four feet. Their walls are slickensided, but do not show any traces of weathering. The spaces between the walls are filled with a light gray shale or soapstone.

These fissures, with their fillings, are known to the miners as horsebacks. There is no regularity in the distance between these horsebacks, or clay seams, or in the direction in which they extend. In some mines they are encountered about forty to sixty feet apart, while in others they are separated by a distance of two hundred to four hundred feet, or more. They traverse the coal seam in various directions, no single direction greatly predominating even in the same mine.

The shale filling the fissures is light gray in color and is generally rather soft. In rare cases it is so hard that it emits sparks when struck with a hammer, but usually it soon slakes down into an incoherent mass upon exposure to the air. Where the horseback enters the top of the coal seam the fissure at once becomes





wider. The upper laminæ of the coal, immediately adjacent to the fissure on the overhanging side, are more or less steeply bent downward; the bending or buckling of the layers fading out laterally within a few feet from the fissures. Fragments of the black shale, from the roof of the coal, were seen at many points in the clay filling of the horsebacks from five to twenty-nine inches below the top of the coal. In mine No. 5 of the Springfield Coal Mining Company, a fragment of coal, six inches long and three fourths of an inch in thickness was found in the clay of a horseback nine inches below the bottom of the coal seam.

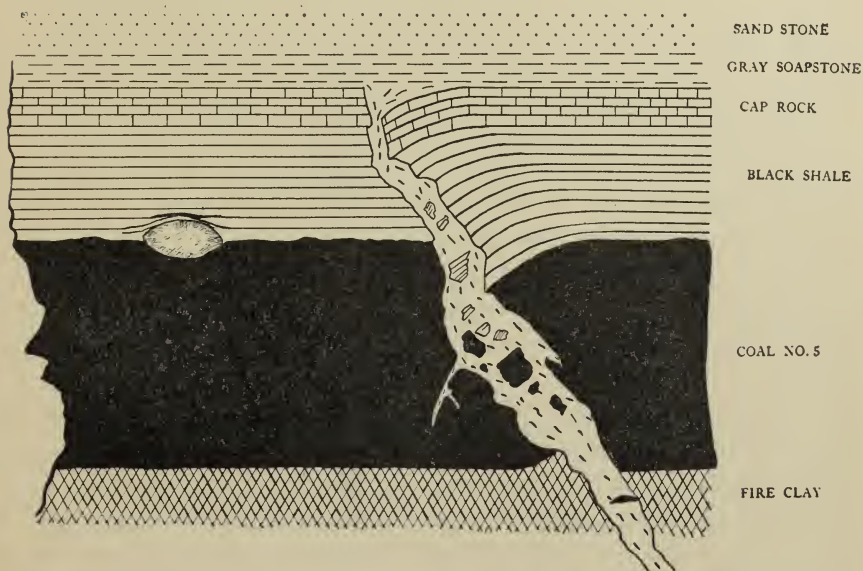


FIG. 21. Typical Clay seam or horseback in Mine No. 5 of the Springfield Coal Mining Co.

In the mine last mentioned there were seen in three of the horsebacks a slight upward bending of the lower edge of the coal on the side of the fissure opposite to that in which the down bending at the top occurred. This upward bending at the bottom, however, is only one third to one half as great as the down bending of the coal at the top of the seam in the same horseback. When the clay seam passes into the coal bed in a nearly vertical

direction there is a down bending of the coal at the top of the seam on each side of the fissure. However, the more nearly vertical the direction in which the horseback cuts through the coal, the less is the distance through which the edges at the top and bottom of the seam are bent.

In no instance was there seen a true faulting of the beds. I wish to emphasize the fact that in no case was there a slipping of the middle part of the coal seam on one side of the fissure above the level of the corresponding part of the seam on the opposite side. The only vertical displacement is a downward pushing of the cap rock and roof shale, and a down bending of the upper laminae of the coal on the overhanging side of the fissure, through a vertical distance of from two to twenty inches; and, less frequently, a much smaller upward bending of the lower edge of the coal seam on the opposite side of the fissure, as shown in Fig. 21.

In this area the fissures have a very limited vertical extent. In the Mechanicsburg mine a coal seam was formerly worked about thirty-five feet above the No. 5 bed which is at present being mined. Although these two coal seams are separated by an interval of less than forty feet, the No. 5 coal is traversed by numerous clay seams, while none were encountered in the upper bed.

It seems certain that there was a somewhat ready yielding of the coal mass in a lateral direction when the fissures were formed. This is shown in the fact that the walls of the fissures are wider apart in the coal bed than in the overlying roof shale and cap rock. The clay seams always cut the bed in an oblique or a vertical direction, never following partings or stratification planes of the coal seam, even where these are well marked. The amount of downward slipping of the cap rock is always less than the extent to which the upper edge of the coal seam overhanging the fissure is bent downward. All of the movement, both horizontal and vertical, that has taken place in connection with the clay-filled fissures, seems to have been made possible by the yielding of the materials within the coal seam itself.

That the coal offered accommodation to the strains that caused

the formation of the fissures is shown by the fact that within the coal seam the smaller fissures often divide into a number of branches which eventually die out without passing entirely through the bed.

The clay filling the fissures is thought to have been pressed downward through the break in the cap rock and roof shale, into the coal, from the bed of gray shale or soapstone overlying the cap rock. As this clay was forced downward into the fissures it caught the overhanging and unsupported edges of the cap rock, roof shale and coal, bending those edges downward on the overhanging side of the fissure.

That this clay was, for the most part, squeezed downward from above the coal horizon is indicated by the manner in which the upper edge of the coal overhanging the fissure has been bent downward to a much greater extent than the lower edge of the coal on the foot-wall side has been forced upward. It is shown in the fact that fragments of black shale from the roof of the coal are common in the clay filling of the horseback several inches below the top of the coal seam; the fragments of coal also occur in the clay some inches below the bottom of the seam. In no case were coal fragments found in the clay filling at a level higher than the top of the coal.

Suggested Origin of the Local Clay Seams.—It is thought that the formation of the clay-filled fissures was intimately related to the character of the beds above the No. 5 coal. It is probable that the character of the underlying fire clay, which here is dry and does not creep readily, is also a conditioning factor. The fissures were not formed, as at present, until after the vegetal mass composing the coal seam had been compressed to near its present volume. This is shown in the fact that the clay seams show no bending or buckling, such as would result if much compression of the coal had occurred after the horsebacks were completely formed. Where the lower edge of the coal rests upon the clay filling the horseback, the laminae are not curved upward adjacent to the fissure as they would be if the coal at a distance from the fissure had been compressed or set-

tled downward since the horseback was formed. That a degree of consolidation of the coal sufficient to permit of jointing had occurred prior to the formation of the horsebacks is shown by the fact that in some places the clay from the fissures has spread into the joints of the coal adjacent to the horseback.

Campbell¹ suggests that joints are developed early in the process of coal formation, and that the carbonization of the coal beyond the lignite condition, depends upon the presence of joints and cleavage planes along which the gases could find a way of escape. If this is the case, there would be a considerable amount of compression and contraction of the coal seam after the joints were formed, before the vegetal mass reached the condition of bituminous coal.

It is assumed that as the mass of vegetal material, under the weight of overlying sediments, was slowly transformed into coal, there would be somewhat unequal contraction in different parts of the seam, owing to the lack of homogeneity of the vegetal materials making up the coal beds; and that the contraction of the coal materials continued long after a high degree of consolidation of the coal had taken place. So long as the materials possessed some degree of mobility the unequal shrinking in the different parts of the coal seam would be equalized by the movement of some of the mass towards the points of least pressure. When the consolidation reached a certain point such adjustment would be no longer possible. After this, the continued unequal shrinking of the vegetal mass would cause unequal strains in the roof of the coal under its load of superposed sediments.

If the roof of the coal seam was a soapstone, or somewhat plastic shale, the mobility of the shale particles would permit this zone to adjust the inequalities of strain resulting from the unequal contraction of the coal seam. Such conditions exist in the roof of coal No. 6, in the Carterville-Zeigler district of southern Illinois. Rock rolls or depressions in the top of the coal are here common, but no clay seams penetrate the coal bed. In the vicinity of these rolls the roof shale is cut by slickensided zones

¹ Campbell, *ECONOMIC GEOLOGY*, Vol. I., No. 1, p. 30.

for a distance of several feet from the center of the roll, indicating a considerable lateral movement in the shale in accomplishing the adjustment of the strains. However, the roof of coal No. 5 is a hard, brittle shale whose constituent particles do not possess the mobility requisite for such adjustment. If the limestone cap rock was very thick it might be able to withstand, without fracture, the unequal strain due to the unequal contraction in the underlying coal seam. The cap rock of this coal is thin, averaging only twelve to fourteen inches. The combined strength of the roof shale and cap rock was not sufficient to withstand the unequal strain to which they were subjected, and fissuring of the beds resulted.

Immediately above the cap rock of this coal seam is a bed of rather soft, gray shale or soapstone whose particles were sufficiently mobile to bring about adjustment in the unequal strains which, by the fissuring of the roof shale and cap rock, had been transferred to this higher horizon. The materials from this shale horizon were immediately squeezed downward through the fissures as a wedge into the coal seam until the inequality of pressure was adjusted. Under these conditions the place in which adjustment was accomplished was limited to a narrow zone below the point where the fracture was made in the roof shale and cap rock. Hence the effects are confined to a narrow zone horizontally but they became thus strongly marked in a vertical direction.

It is probable that from time to time, as the shrinking in the coal mass continued, more clay was forced downward into the coal seam, fissuring it still deeper and spreading the walls of the fissure constantly wider apart. The abundant evidences that the clay filling the fissures in the Springfield coal seam was pressed down from above the coal have been given on a preceding page. In this manner also the slickensiding was accomplished by the slipping of the clay in the fissure, and not by the movement of the walls of the fissure upon each other.

It is thought that the principle of unequal contraction in the different parts of the coal seam, during the progress of its con-

solidation, applies also in the formation of the more common types of rock rolls in the top of coal seams. The character and sequence of the beds above the coal are considered the chief factors in determining whether rolls or clay seams will be formed in the adjustment of the strains arising from such unequal contraction.



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